

## Attachment 1

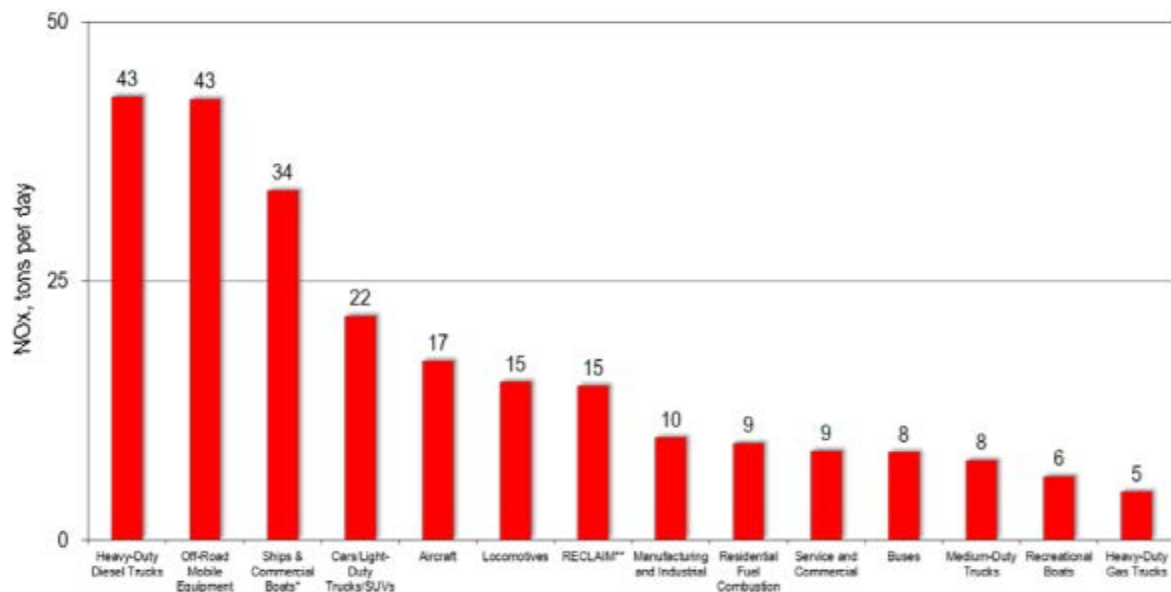
### Emission Inventory – Locomotives South Coast AQMD

## Emissions Inventory

This section describes emissions estimate methodology and emission inventory sources. The off-road equipment emissions inventory is estimated by the California Air Resources Board (CARB), which includes construction and mining equipment, industrial and commercial equipment, lawn and garden equipment, agricultural equipment, ocean-going vessels, commercial harbor craft, locomotives, cargo handling equipment, pleasure craft, and recreational vehicles. U.S. EPA and CARB have primary authority to regulate emissions from mobile sources. U.S. EPA's authority applies to aircraft, locomotives, ocean-going vessels, and some categories of on- and off-road mobile equipment. The future emission forecasts are primarily based on demographic and economic growth projections provided by Southern California Association of Governments(SCAG).

Mobile sources currently emit over 80 percent of regional NO<sub>x</sub> emissions, and therefore mobile source controls must be a significant part of the control strategy. As shown in Figure 1, the on-road heavy-duty truck category is projected to comprise the single largest contributor to regional NO<sub>x</sub> in 2023. Other equipment involved in goods movements, such as marine vessels, locomotives and aircraft, are also substantial NO<sub>x</sub> sources.

**Figure 1**



The emissions model methodology for the freight locomotive category was using the data from the Surface Transportation Board and Federal Highway Administration's Freight Analysis Framework. Population information was derived from the Association of American Railroads' population data.

The emissions inventory is generally based on the locomotives' total activity, fuel usage, and equipment age/Tier. Emissions for each pollutant are calculated for each railroad operating in the area.

There are four types of locomotive including line-haul, switcher, short line, and passenger locomotives. The line-haul is categorized as Class I freight rail, operated in California by Burlington Northern Santa Fe (BNSF) and Union Pacific Railroad (UP). The switcher moves railcars in or around rail yards. The short line is categorized as Class III rail for local and regional rail operation hauling freight and provide switching over a small network. The passenger locomotive provides commuter, intercity and interstate passenger rail lines. Each railroad may have two kinds of emissions: line-haul and yard. (Some small railroads that only operate in a rail yard will not have line-haul emissions.)

For Class I line-haul locomotives, emissions are calculated by multiplying the amount of fuel consumed in the inventory area by the appropriate emission factors for each species. The following calculation is performed for each railroad and each species of interest. The results for each railroad are then summed to obtain the total Class I railroad emissions in the inventory area. The basic equation, with conversion factors, is given below.

$$\left[ \begin{array}{c} \text{Railroad} \\ \text{Line Haul Emissions} \\ \text{Tons / year} \end{array} \right] = \left[ \begin{array}{c} \text{Annual Railroad} \\ \text{fuel use} \\ \text{gallons / year} \end{array} \right] \cdot \left[ \begin{array}{c} \text{Emission Factor} \\ \text{pounds per} \\ \text{thousand gallons} \end{array} \right] \cdot \frac{1 \text{ ton}}{2000 \text{ lb}} \cdot \frac{\text{thousand gallons}}{1000 \text{ gallons}}$$

The two conversion factors can be combined to give the working equation shown below.

$$\left[ \begin{array}{c} \text{Railroad} \\ \text{Line Haul Emissions} \\ \text{Tons / year} \end{array} \right] = \frac{\left[ \begin{array}{c} \text{Annual Railroad} \\ \text{fuel use} \\ \text{gallons / year} \end{array} \right] \cdot \left[ \begin{array}{c} \text{Emission Factor} \\ \text{pounds per} \\ \text{thousand gallons} \end{array} \right]}{2,000,000}$$

South Coast AQMD's 2016 Air Quality Management Plan (AQMP) shows that the 522 tons per day (tpd) of total Basin NOx 2012 emissions are projected to drop to 255 tpd and 214 tpd in the 8-hour ozone attainment years of 2023 and 2031, respectively, due to the continued implementation of already adopted regulatory actions. The analysis suggests that total Basin emissions of NOx must be reduced to approximately 141 tpd in 2023 and 96 tpd in 2031 to attain the 8-hour ozone standard. This represents an additional 45% reduction in NOx in 2023, and an additional 55% NOx reduction beyond 2031 levels.

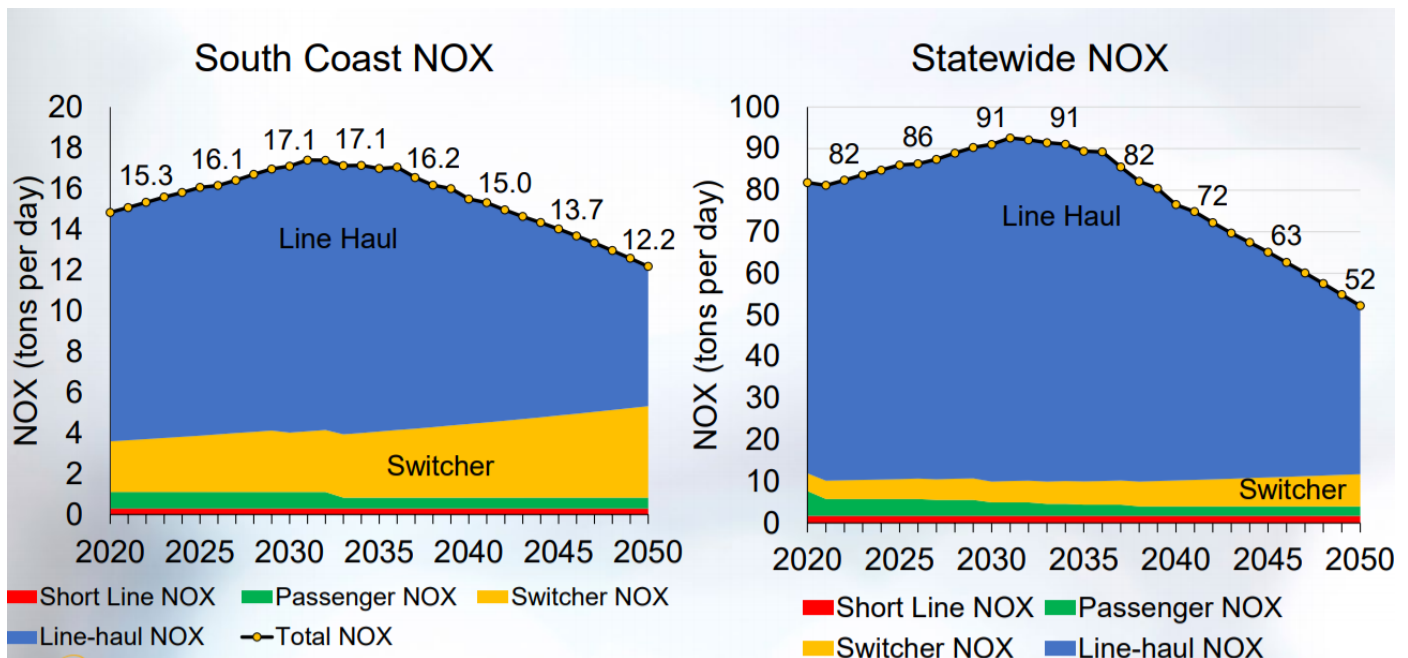
CARB is working on compiling the 2020 locomotive inventory and revising the state locomotive regulations. The latest CARB locomotive inventory published for 2012, estimated that Union Pacific Railroad (UP) and BNSF interstate line-haul locomotives contribute to 85% of statewide locomotive NOx emissions (see Table 1). UP and BNSF operate over 10,000 interstate line-haul locomotives annually within California. Based on the CARB's data showed in Figure 1, in 2020, locomotives contribute to 80 tpd of NOx; over 18% of the locomotive NOx emissions are in SCAB. The percentage of locomotive category emissions in the basin is likely to increase with the reduced emissions from other mobile source categories by new regulations adoption and implementation of cleaner engine technologies.

**Table 1. California Locomotive and % of Statewide Locomotive NOx Emissions**

Type of Service	Locomotive Category	Statewide Locomotive NOx Emissions (%)
Freight	Class I Interstate Line Haul Locomotive	85
	Class I Interstate Locomotives	8
	Class III Short line Interstate Locomotives	1
	Military and Industrial Intrastate Locomotives	<0.4
Passenger	Passenger Intrastate MHP Locomotives	6

Data source: CARB's 2016 Technology Assessment: Freight Locomotives

**Figure 2. Locomotive NOx Emissions**



The locomotive inventories reflect the 2008 U.S. EPA locomotive regulations and adjustments due to the economic activity for passenger and switch locomotive categories. However, for the largest category of locomotive emissions, linehaul locomotives, the emissions model methodology was completely revised recently as the comparisons shown in 2016 and 2020 AQMP. In addition, activity was updated using data for the Surface Transportation Board and Federal Highway Administration's Freight Analysis Framework. Population information was derived from the Association of American Railroads' population data and the U.S. EPA's survival curve.

The data source for line-haul locomotive, including population, activities, locations, Tiers, and emission factors, are from South Coast MOU Data, UP, BNSF, US EPA locomotive factors, and Primarily Freight

Analysis Framework. There are four main locomotive Tiers, as indicated below. The standards of new engines got progressively cleaner over time. The Tier 4 engines achieve 93% NOx and 95% PM reduction compared to an uncontrolled engine. Tier 0+/1+/2+ mean remanufactured engines.

Tier	NOx (g/bhp-hr)	PM10 (g/bhp-hr)
Pre-Tier 0	13.0	0.32
Tier 0	8.6	0.32
Tier 0+	7.2	0.20
Tier 1	6.7	0.32
Tier 1+	6.7	0.20
Tier 2	4.95	0.18
Tier 2+	4.95	0.08
Tier 3	4.95	0.08
Tier 4	1.0	0.015

The Tables below show ton per day (tpd) emissions from line-haul and all locomotives' in SCAB. The 2020 update has some significant changes on the linehaul emissions projection. The 2022 AQMP inventory is preliminary and subject to upcoming revisions. The 2031 line-haul emissions projection in 2020 AQMP increased significantly compared with the estimates conducted in 2016 due to the changes in inventory methodology. The modeling concept includes understanding the current mix and projecting future Tier mix based on the last decade of rail visits and remanufacturing behavior. The locomotive engines are not only replaced but remanufactured to different Tier standards. The remanufactured engine means only to meet the original Tier or overhauled in kind and is not required to achieve significant emissions reduction.

#### 2016 AQMP

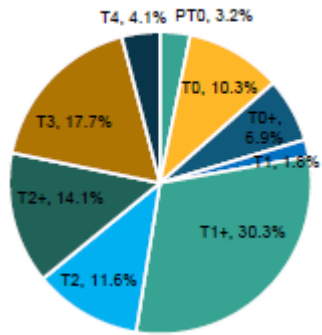
	Linehaul (tpd)	All Locomotives (tpd)	% Linehaul Emissions
2018	10.6	17.7	60%
2031	3.08	10.7	29%

#### 2020 AQMP

	Linehaul (tpd)	All Locomotives (tpd)	% Linehaul Emissions
2018	11.4	15.0	76%
2031	13.6	17.7	77%

In 2018, only 4% of the locomotive population was Tier 4. In 2019, Tier 4 locomotive population increased to 5.6%. The Tier 4 locomotive purchases have been steadily decreasing since the standards went into effect in 2015.

2018 SC MOU



2019 CALH

